US010502262B2

(12) **United States Patent**
Stamps et al.

(10) **Patent No.: US 10,502,262 B2**
(45) **Date of Patent: Dec. 10, 2019**

(54) **INCREASED CAPACITY SPHERICAL LINED BEARINGS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **15/646,546**

(22) Filed: **Jul. 11, 2017**

(65) **Prior Publication Data**

US 2017/0307009 A1 Oct. 26, 2017

Related U.S. Application Data

(63) Continuation of application No. 13/283,973, filed on Oct. 28, 2011, now Pat. No. 9,702,402.

(51) **Int. Cl.**

F16C 23/04 (2006.01)
B64C 27/48 (2006.01)
B64C 27/82 (2006.01)

(52) **U.S. Cl.**

CPC ***F16C 23/043*** (2013.01); ***B64C 27/48*** (2013.01); ***B64C 27/82*** (2013.01); *F16C 2326/43* (2013.01); *Y10T 29/49332* (2015.01)

(58) **Field of Classification Search**

CPC B64C 27/48; F16C 23/043

See application file for complete search history.

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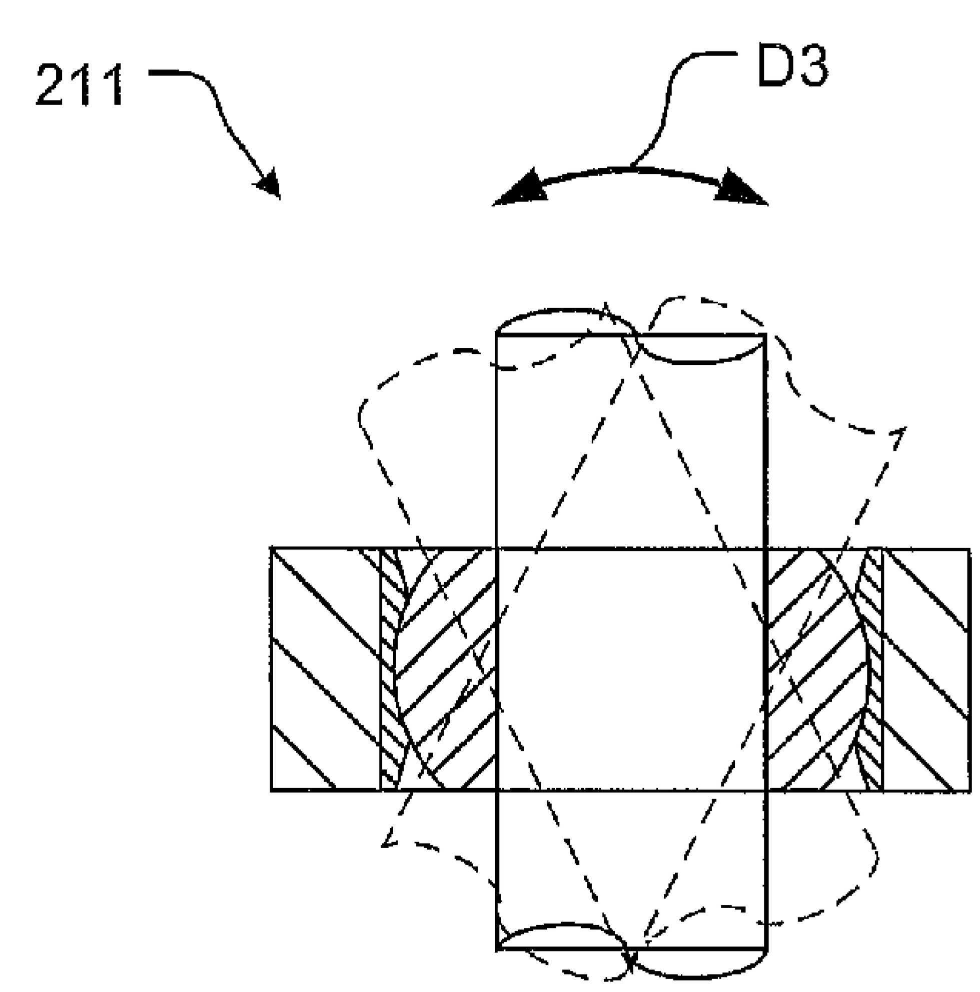
(57) **ABSTRACT**

A rotary system and method to control feathering movement of a rotor blade. The system having a yoke arm configured to rotate a rotor blade. A first bearing and a second bearing are utilized to secure the rotor blade to the yoke arm and are configured to restrict longitudinal and transverse movement, while allowing feathering movement of the rotor blade relative to yoke arm.

5 Claims, 5 Drawing Sheets



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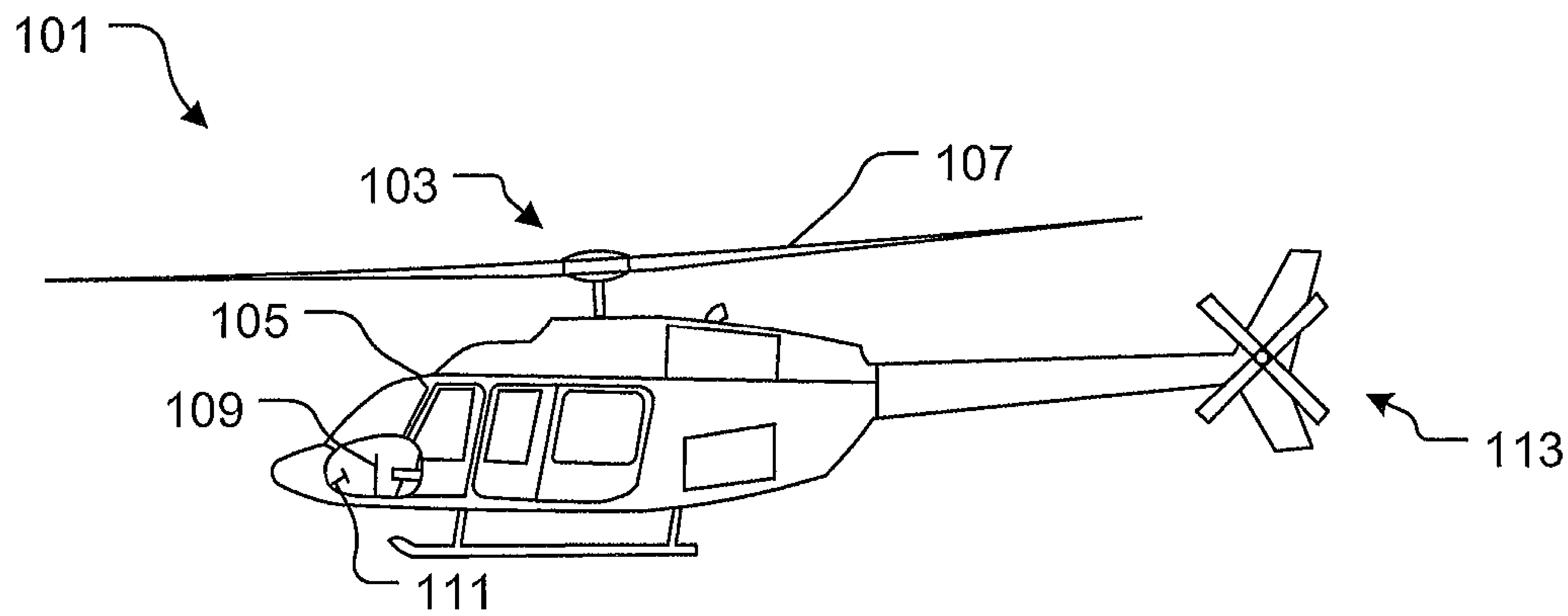

FIG. 1

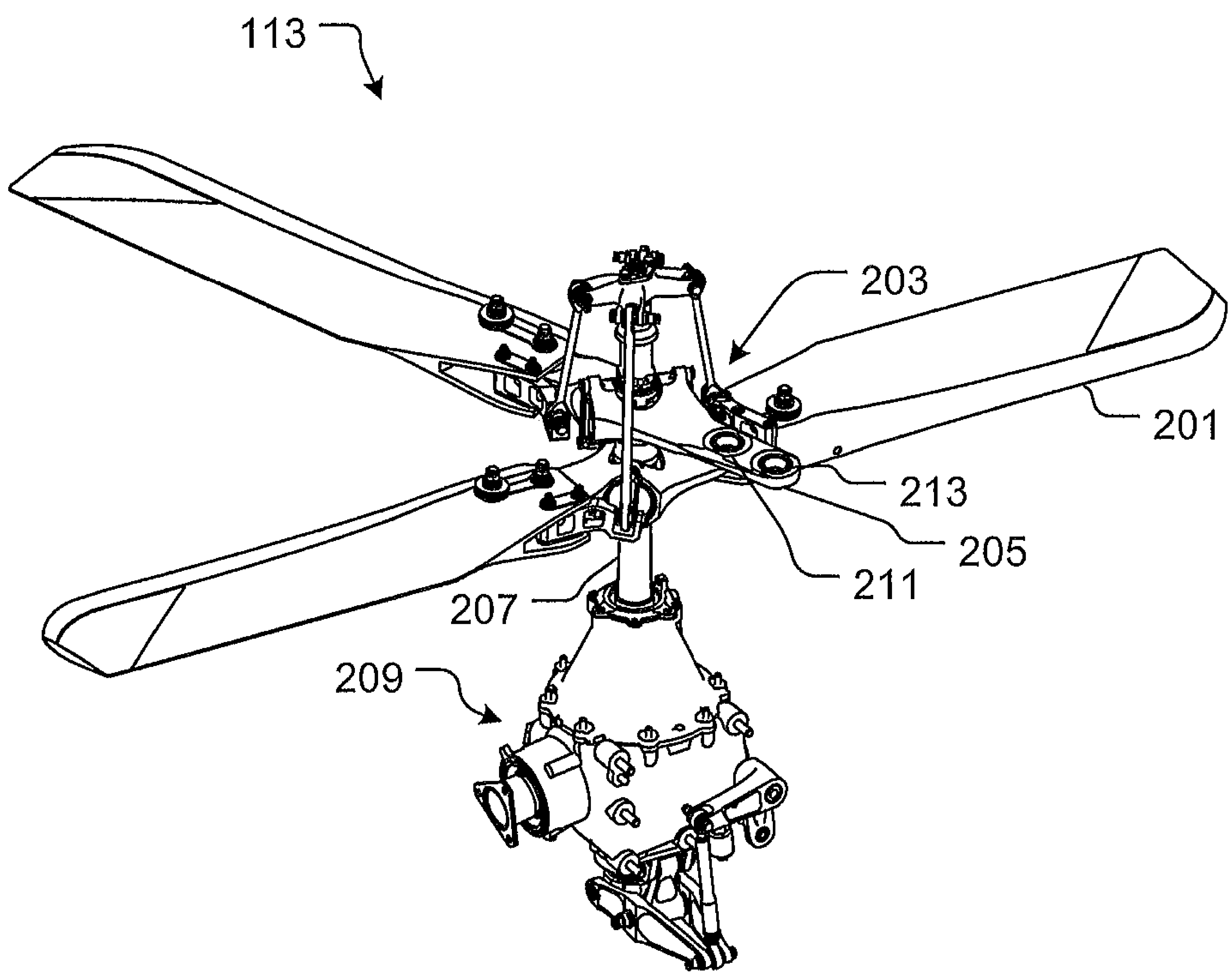

FIG. 2

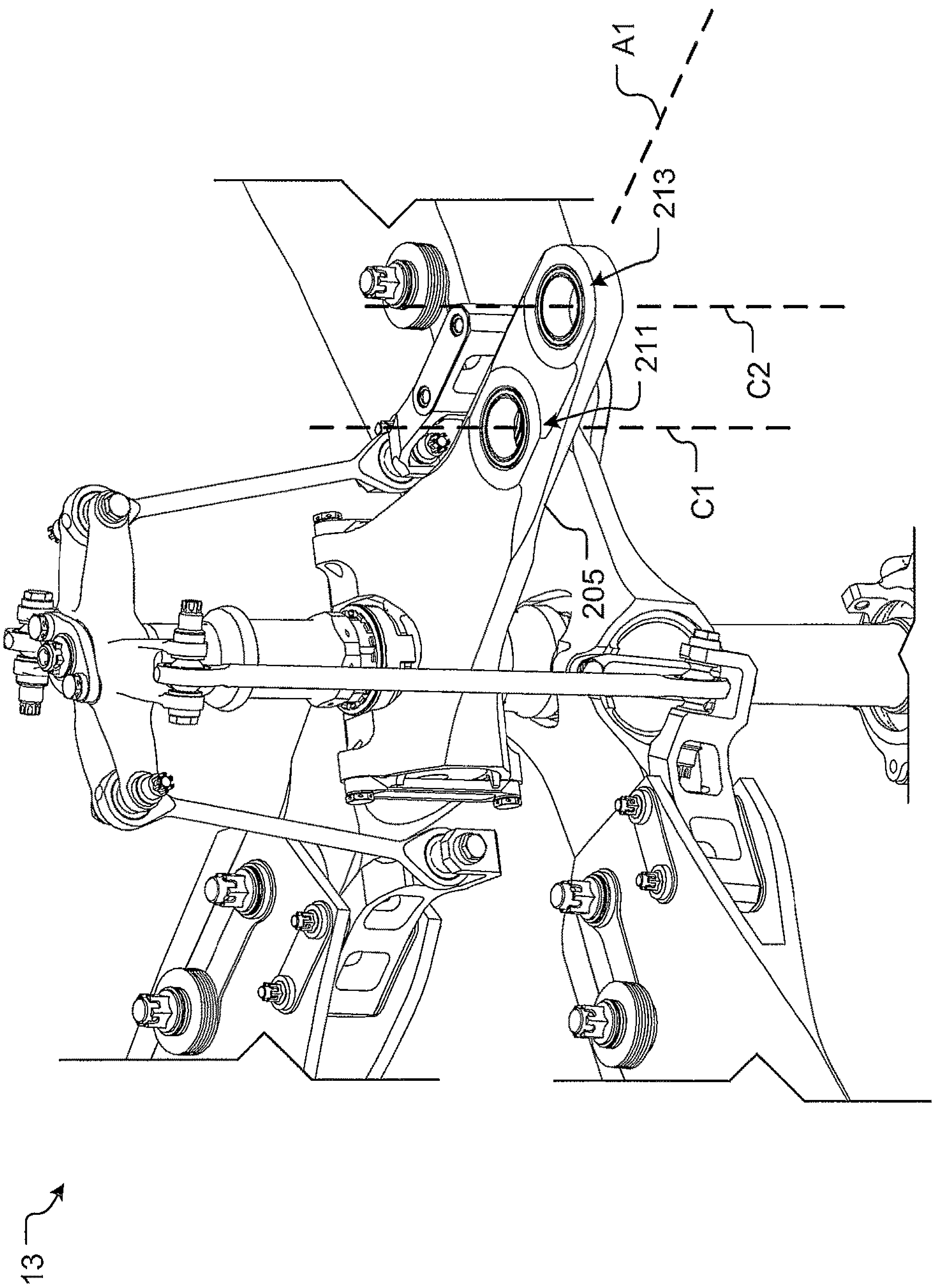

FIG. 3

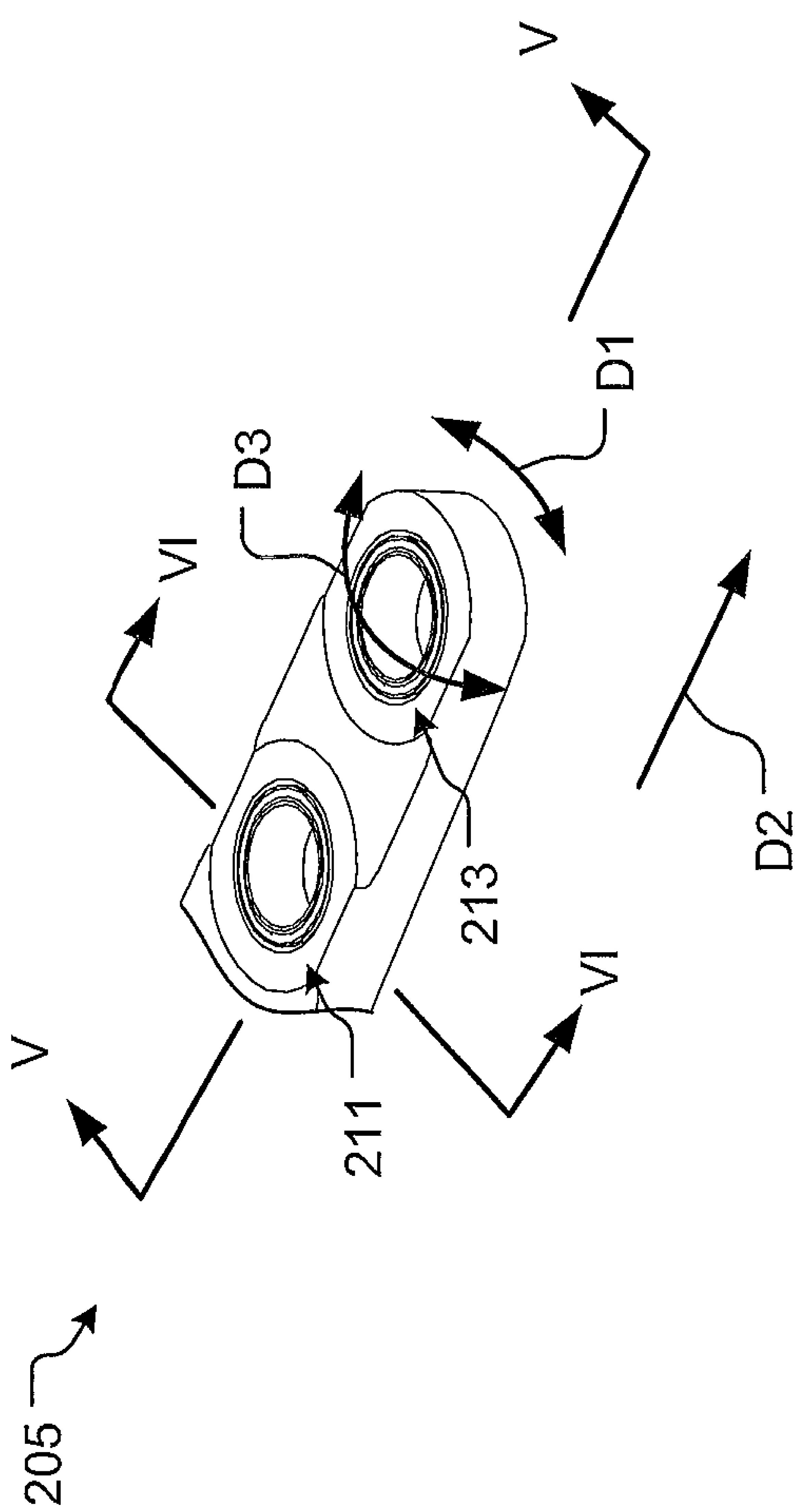

FIG. 4

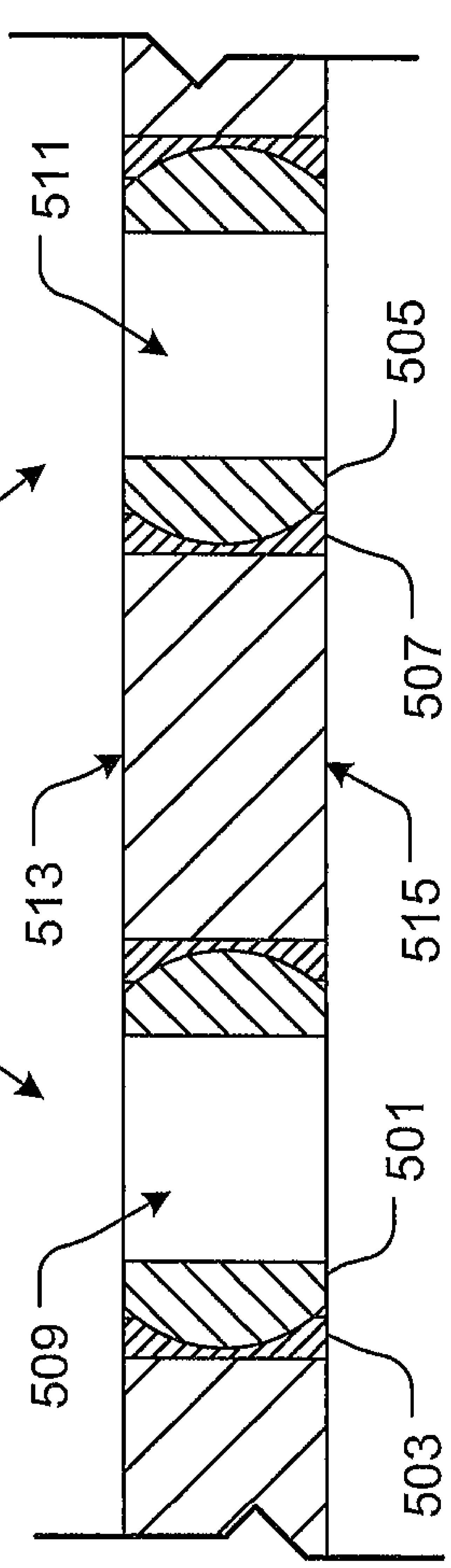

FIG. 5

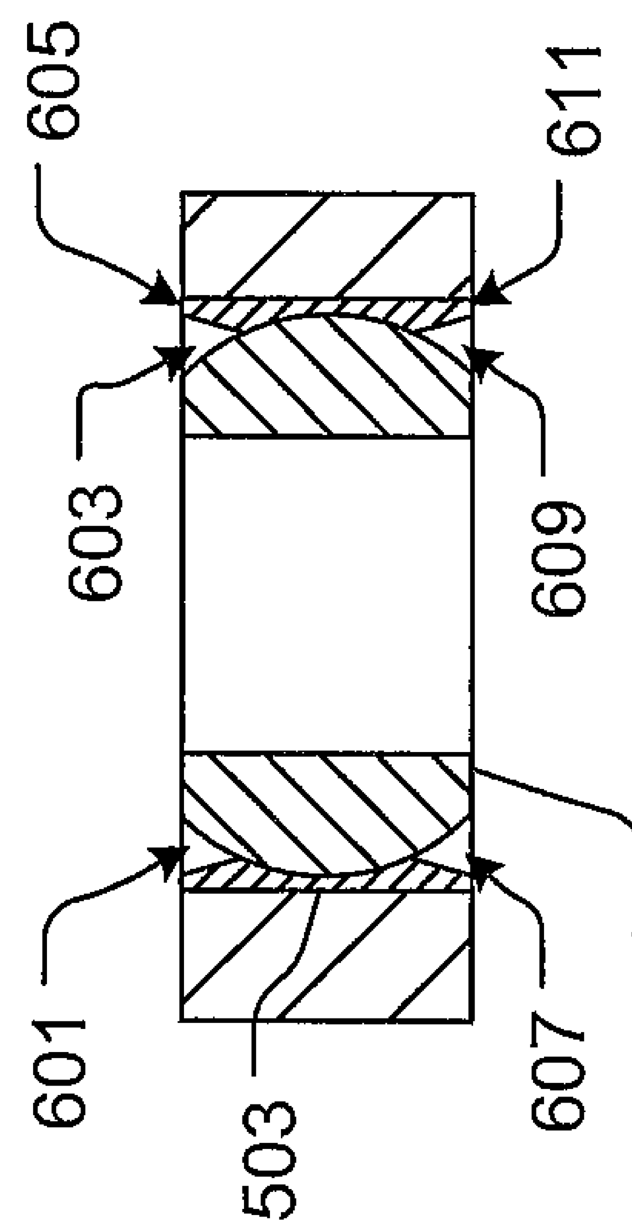

FIG. 6

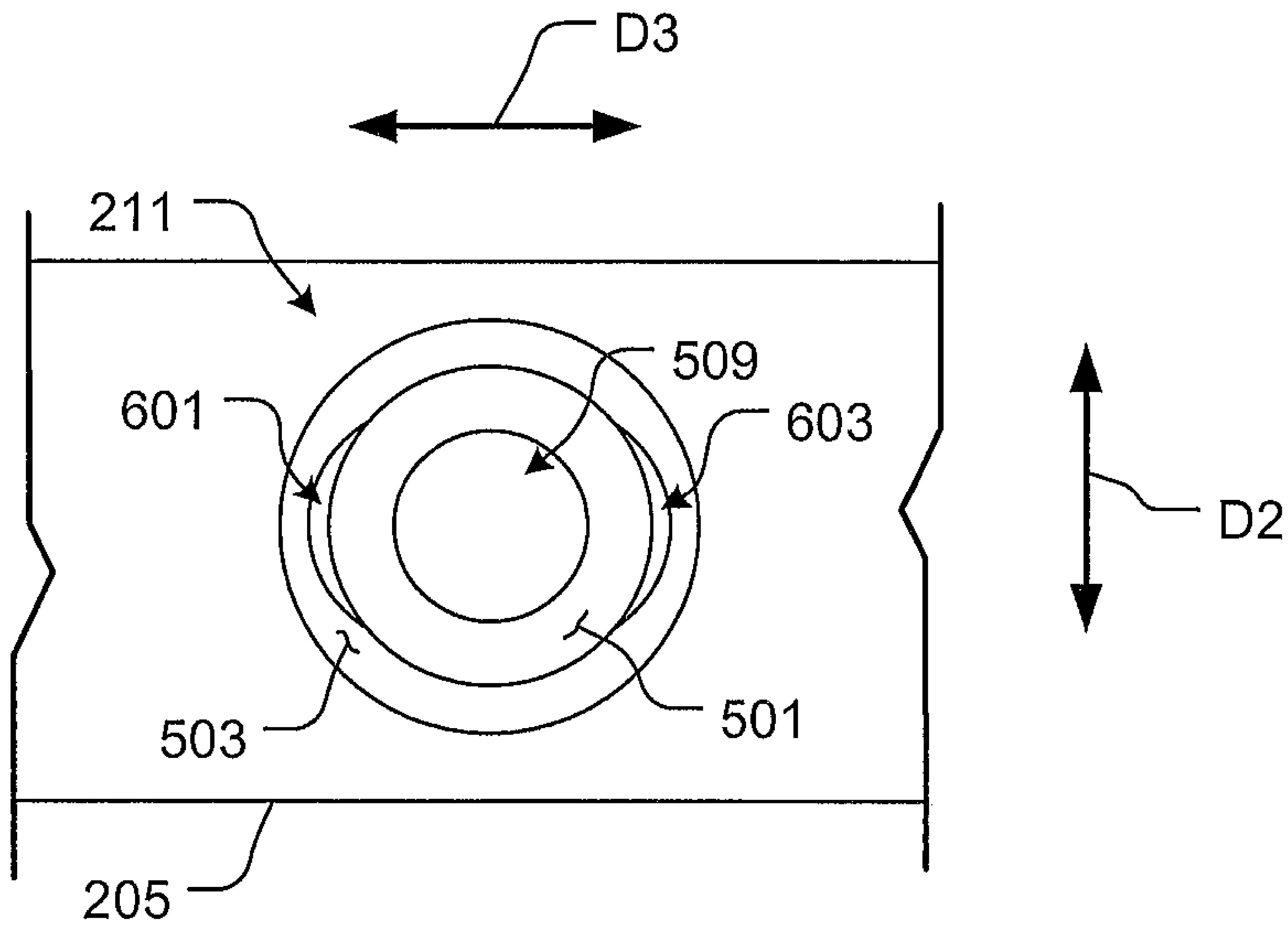

FIG. 7

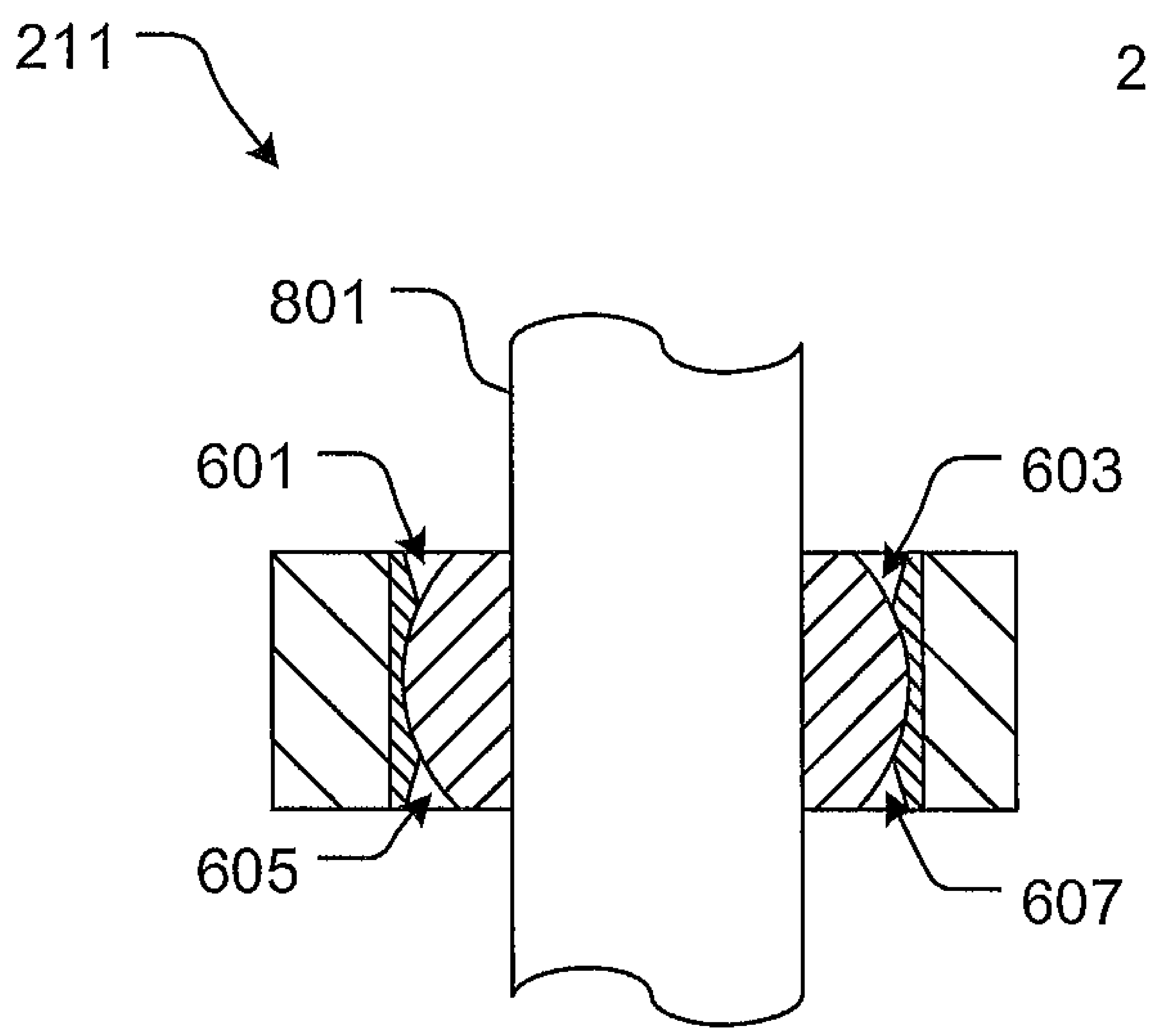

FIG. 8A

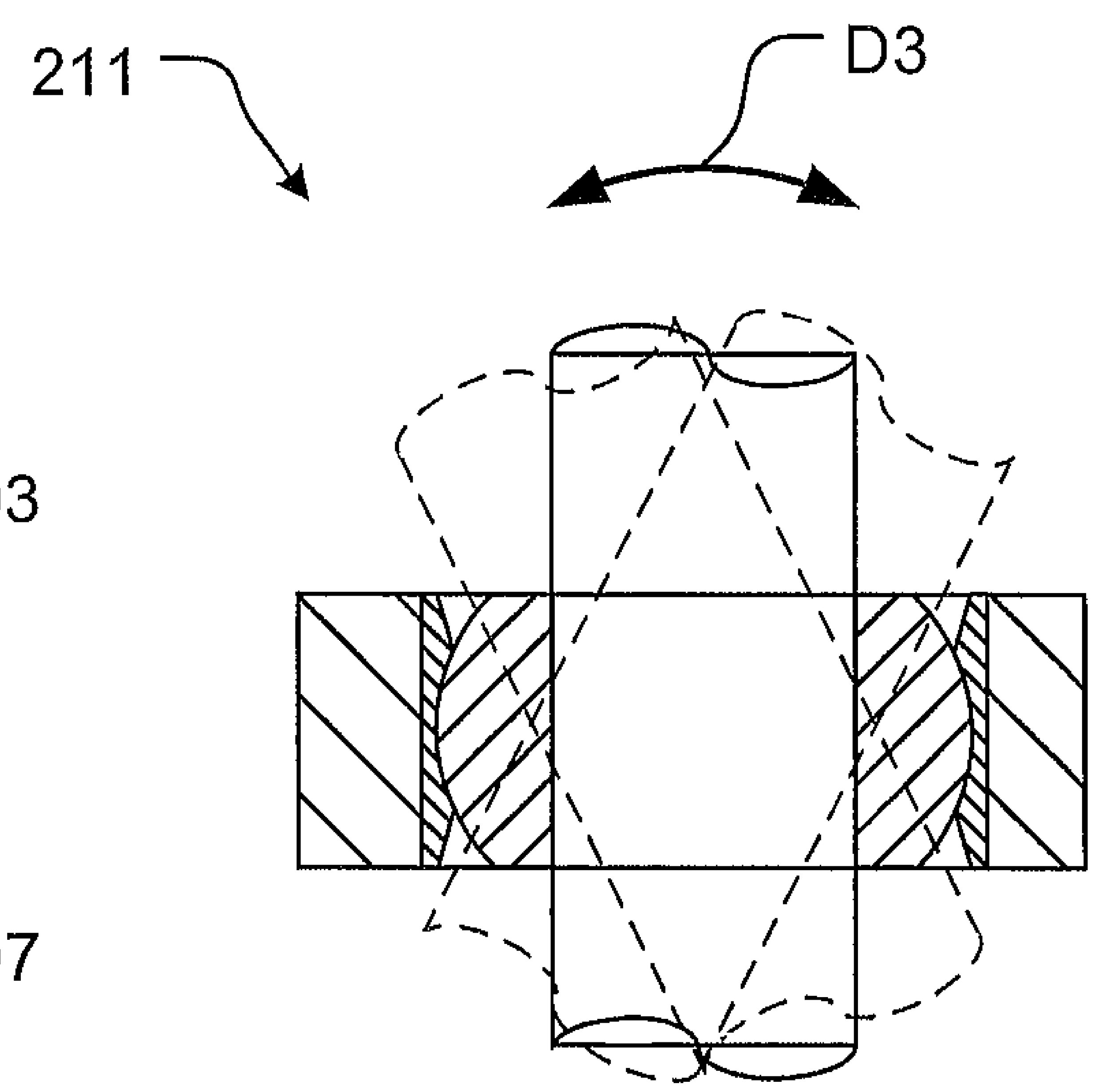

FIG. 8B

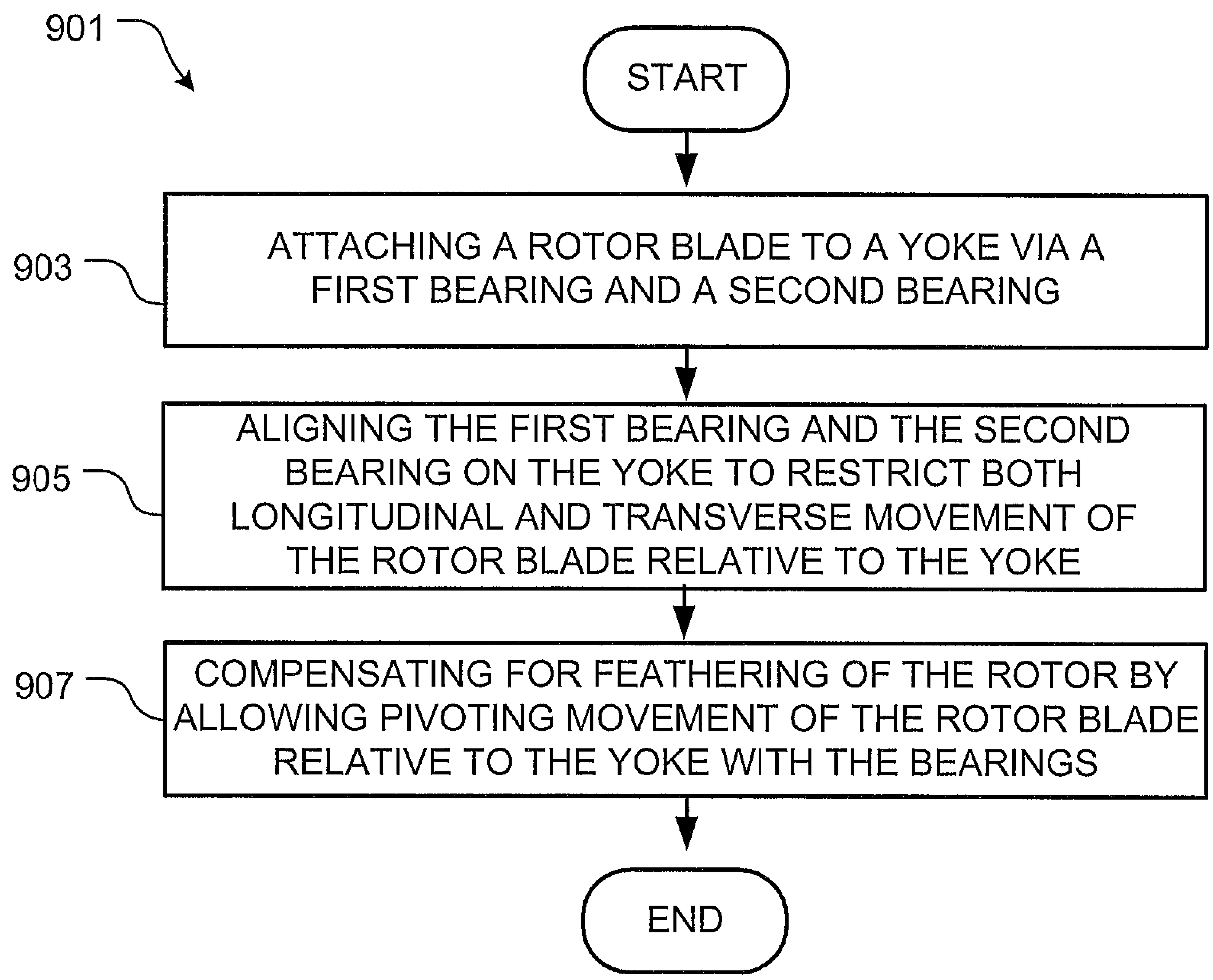
901
START
903
ATTACHING A ROTOR BLADE TO A YOKE VIA A FIRST BEARING AND A SECOND BEARING
905
ALIGNING THE FIRST BEARING AND THE SECOND BEARING ON THE YOKE TO RESTRICT BOTH LONGITUDINAL AND TRANSVERSE MOVEMENT OF THE ROTOR BLADE RELATIVE TO THE YOKE
907
COMPENSATING FOR FEATHERING OF THE ROTOR BY ALLOWING PIVOTING MOVEMENT OF THE ROTOR BLADE RELATIVE TO THE YOKE WITH THE BEARINGS
END

FIG. 9

INCREASED CAPACITY SPHERICAL LINED BEARINGS

BACKGROUND

1. Field of the Invention

The present application relates generally to rotary systems, and more specifically, to a tail rotary system having spherical lined bearings.

2. Description of Related Art

Conventional tail rotors are well known in the art for effectively controlling yaw movement of a rotary aircraft. The tail rotor utilizes a plurality of rotor blades for creating thrust, and during flight, the rotor blades tend to feather, thereby creating an undesired movement that could cause the tail rotor to fail.

In some embodiments, conventional tail rotary systems include rotor blades that rigidly attach to the yoke arms. These embodiments are effective in restricting rotor blade feathering movement; however, the embodiments are prone to failure due to the blade feathering stresses exerted on the yoke arm.

Although great strides have been made in the field of tail rotary systems, many shortcomings remain.

DESCRIPTION OF THE DRAWINGS

The novel features believed characteristic of the invention are set forth in the appended claims. However, the invention itself, as well as a preferred mode of use, and further objectives and advantages thereof, will best be understood by reference to the following detailed description when read in conjunction with the accompanying drawings, wherein:

FIG. **1** is a side view of a rotary aircraft utilizing a rotary system of the present application;

FIG. **2**-**3** are oblique views of a tail rotor of the rotary aircraft;

FIG. **4** is a partial oblique view of a yoke arm of the tail rotor of FIG. **2**;

FIG. **5** is a cross-sectional view of the yoke arm of FIG. **4** taken at V-V;

FIG. **6** is a cross-sectional view of the yoke arm of FIG. **4** taken at VI-VI;

FIG. **7** is a top view of a spherical bearing of FIG. **4**;

FIGS. **8**A and **8**B are cross-sectional views of the spherical bearing of FIG. **6** shown operably associated with a mast; and

FIG. **9** is a flow chart depicting the preferred method.

While the system and method of the present application are susceptible to various modifications and alternative forms, specific embodiments thereof have been shown by way of example in the drawings and are herein described in detail. It should be understood, however, that the description herein of specific embodiments is not intended to limit the invention to the particular embodiment disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the process of the present application as defined by the appended claims.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Illustrative embodiments of the system and method are provided below. It will of course be appreciated that in the development of any actual embodiment, numerous implementation-specific decisions will be made to achieve the developer's specific goals, such as compliance with system-related and business-related constraints, which will vary from one implementation to another. Moreover, it will be appreciated that such a development effort might be complex and time-consuming, but would nevertheless be a routine undertaking for those of ordinary skill in the art having the benefit of this disclosure.

The tail rotary system of the present application overcomes common disadvantages associated with conventional tail rotors by providing effective means for controlling feathering forces created by the rotor blades attached thereto during flight. Specifically, the tail rotor includes one or more bearings for securing the rotor blades to a yoke arm of a hub retention system. The bearings are aligned in a linear fashion so as to prevent longitudinal and transverse movement of the blade relative to the yoke arm, yet allowing feathering movement of the rotor blade. The bearings also include cutouts selectively positioned in the bearing housing for increasing feathering movement.

The tail rotary system of the present application will be understood, both as to its structure and operation, from the accompanying drawings, taken in conjunction with the accompanying description. Several embodiments of the system are presented herein. It should be understood that various components, parts, and features of the different embodiments may be combined together and/or interchanged with one another, all of which are within the scope of the present application, even though not all variations and particular embodiments are shown in the drawings. It should also be understood that the mixing and matching of features, elements, and/or functions between various embodiments is expressly contemplated herein so that one of ordinary skill in the art would appreciate from this disclosure that features, elements, and/or functions of one embodiment may be incorporated into another embodiment as appropriate, unless described otherwise.

Referring now to the drawings wherein like reference characters identify corresponding or similar elements throughout the several views, FIG. **1** is a side view of a rotary aircraft **101** utilizing the tail rotary system of the present application. Although depicted with the exemplary type of rotary aircraft **101**, it will be appreciated that the features disclosed herein are easily adaptable for use with other types of rotary aircraft.

Rotary aircraft **101** comprises a main rotary system **103** positioned above fuselage **105** for rotating two or more rotor blades **107**. The main rotary system **103** is controlled with a plurality of controllers carried within fuselage **105**. During flight, the cyclic controller **109** and/or pedal **111** are manipulated to create vertical, horizontal, and yaw flight direction. Aircraft **101** is further provided with a tail rotor **113** that creates yaw movement during flight. A detailed description of tail rotor **113** is provided below.

Turning next to FIGS. **2** and **3** in the drawings, oblique views of tail rotor **113** according to the preferred embodiment of the present application are shown. In the exemplary embodiment, tail rotor **113** includes four rotor blades **201**; however, it will be appreciated that tail rotor **113** is easily adaptable for use with more of less blades in an alternative embodiment. It should be understood that for clarity, one of the four blades is removed to illustrate the bearings associated with the tail rotor. Blades **201** are configured to couple with a hub retention member **203** having four yoke arms **205**, which in turn is rotatably attached to a mast **207** and an engine transmission **209**.

Tail rotor **113** is further provided with two or more bearings: a first bearing **211** and a second bearing **213**, both bearings being configured to allow slight feathering movement of the rotor relative to the yoke arm. In the preferred embodiment, bearings **211** and **213** are spherical bearings that sit flush with an upper surface and a lower surface of yoke arm **205**; however, it will be appreciated that other types of bearings and devices could be used in lieu of the preferred embodiment. As is described more fully below, the spherical bearings allow for slight feathering motion of the rotor blades, which provides significant advantageous over conventional tail rotors, namely tail rotors having rotor blades rigidly attached to the yoke arm.

Referring specifically to FIG. **3**, yoke arm **205** has length extending along a longitudinal axis A**1** and both bearings **211** and **213** have centerlines C**1** and C**2**, respectively, that are aligned in a linear fashion such that both centerlines C**1** and C**2** intersect with the longitudinal axis A**1** of yoke arm **205**.

In FIG. **4**, a partial oblique view of yoke arm **205** is shown. FIG. **4** provides further illustration of the bearings according to the preferred embodiment of the present application. Tail rotor **113** preferably includes two bearings for securing the rotor blade to the yoke arm; however, it will be appreciated that alternative embodiments could include additional bearings in lieu of the preferred embodiment. The two bearing configuration provides means for restricting transverse movement of the rotor blades in direction D**1** and longitudinal movement in direction D**2**; however, the bearings are configured to allow slight feathering movement of the rotor blades in direction D**3** during flight. These features are achieved due to the alignment of the bearings relative to the yoke arm longitudinal axis A**1**, as described above.

In FIG. **5**, a cross-sectional view of yoke arm **205** is shown taken at V-V of FIG. **4**. In the preferred embodiment, both bearings **211** and **213** are spherical bearings, which allow pivoting movement in direction D**3** to compensate for feathering. Bearing **211** comprises of a spherical ball **501** rotatably engaged with a housing **503**, and likewise, bearing **213** comprises a spherical ball **505** rotatably engaged with a housing **507**. Both bearings **211** and **213** include passages **509** and **511**, respectively, as means for securing the blade thereto. In the preferred embodiment, housing **503** extends the entire thickness length of yoke arm **205**, specifically, from a top surface **513** to a bottom surface **515**. This feature increases the contact surface area between housing **503** and spherical ball **501**.

FIG. **6** is a cross-sectional view of yoke arm **205** taken at VI-VI of FIG. **4**. Bearing **211** is further provided with four cutouts extending from the top and bottom surfaces of housing and inwardly into housing **503**. The cutouts are preferably contoured to match the outer contouring of the attachment means received by passage **509**. It should be understood that the cutouts allow additional feathering movement of the rotor blades in direction D**3**, which in turn greatly increases the efficiency of bearing **211**. As is shown, bearing **211** preferably comprises four cutouts: a first cutout **601** and a second cutout **603** extending from a top surface **605** of housing **503**, and a third cutout **607** and a fourth cutout **609** extending from a bottom surface **611** of housing **503**.

In FIG. **7**, a top view of bearing **211** is depicted. FIG. **7** further illustrates the contouring of cutouts **601** and **603**. In the preferred embodiment, cutouts **601** and **603** have a generally circular contouring to match the contouring of the attachment means, i.e., a circular shaft. However, it will be appreciated that cutouts **601** and **603** could easily be manufactured with different geometric contouring in alternative embodiments. It should be understood that the cutouts are selectively machined on outer housing **503** to allow additional pivoting movement of spherical ball **501** in direction D**3** (feathering movement), but not in direction D**2**. It should be appreciated that the combination of bearings **211** and **213** are utilized in conjunction with each other to prevent movement in directions D**1** and D**2**, while allowing pivoting movement in direction D**3**. The cutouts are utilized to increase pivoting movement of the rotor blades during flight.

In FIGS. **8**A and **8**B, the bearings are shown operably associated with an attachment means **801**, which in the preferred embodiment, is a shaft that extends through passage **509**. Attachment means **801** could include a liner placed between the spherical ball **501** and attachment means **801** for providing protection and support. As is depicted in FIG. **8**B, phantom lines of attachment means **801** show feathering movement of the rotor blade relative to the yoke arm. It should be understood that attachment means **801** does not come into contact with housing **503**.

Referring next to FIG. **9**, a flow chart **901** depicting the preferred process is shown. Box **903** shows the first step, which includes attaching a rotor blade to a yoke arm via a first bearing and a second bearing. The next step includes aligning the first bearing and the second bearing on the yoke arm to restrict both longitudinal and transverse movement of the rotor blade relative to the yoke arm, as depicted in box **905**. Finally, box **907** shows the last step, which includes allowing pivoting movement of the rotor blade relative with yoke arm to compensate for feathering during flight.

It is apparent that a system and method with significant advantages has been described and illustrated. The particular embodiments disclosed above are illustrative only, as the embodiments may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. It is therefore evident that the particular embodiments disclosed above may be altered or modified, and all such variations are considered within the scope and spirit of the application. Accordingly, the protection sought herein is as set forth in the description. Although the present embodiments are shown above, they are not limited to just these embodiments, but are amenable to various changes and modifications without departing from the spirit thereof.

What is claimed is:

1. A method to control feathering movement of a rotor blade, comprising:

attaching the rotor blade to a yoke arm via a first attachment means in a first bearing comprising a first pivoting element and a first housing and via a second attachment means in a second bearing comprising a second pivoting element and a second housing;

forming a first aperture extending longitudinally through the first pivoting element along a centerline of the first bearing, the first attachment means extending longitudinally through the first aperture;

forming a second aperture extending longitudinally through the second pivoting element along a centerline of the second bearing, the second attachment means extending longitudinally through the second aperture;

aligning the first bearing and the second bearing on the yoke arm in a linear fashion;

limiting feathering to a first direction and a second direction;

intersecting the centerline of the first bearing with a longitudinal axis of the yoke arm at only a first point;

intersecting the centerline of the second bearing with the longitudinal axis of the yoke arm at only a second point;

allowing pivoting movement of the rotor blade relative to the yoke arm along the first direction and second direction to compensate for feathering during flight;

notching the first housing with a first set of notches to increase the feathering;

notching the second housing with a second set of notches to increase the feathering; and

contouring the first set of notches and the second set of notches to correspond to an exterior surface of the first attachment means and an exterior surface of the second attachment means, respectively, to increase the feathering.

2. The method of claim **1**, further comprising:

restricting both longitudinal and transverse movement of the rotor blade relative to the yoke arm with the first bearing and the second bearing.

3. The method of claim **1**, wherein the step of aligning the first bearing and the second bearing on the yoke arm in a linear fashion locates the first bearing and the second bearing on a plane.

4. A rotary system, comprising:

a yoke arm;

a rotor blade;

a first bearing comprising a first pivoting element and a first housing, the first bearing being carried by the yoke arm and configured to pivotally secure the rotor blade to the yoke arm;

a second bearing comprising a second pivoting element and a second housing, the second bearing being carried by the yoke arm and configured to pivotally secure the rotor blade to the yoke arm;

a first aperture extending longitudinally through the first pivoting element along a centerline of the first bearing, a first attachment means extending longitudinally through the first aperture;

a second aperture extending longitudinally through the second pivoting element along a centerline of the second bearing, a second attachment means extending longitudinally through the second aperture;

four distinct cutouts located in the first housing; and

four distinct cutouts located in the second housing;

wherein the rotor blade is pivotally secured to the yoke arm by the first attachment means and the second attachment means;

wherein the first bearing and the second bearing together allow feathering movement of the rotor blade relative to the yoke arm during flight in only a first feathering direction and a second feathering direction;

wherein at least two of the four distinct cutouts located in the first housing are contoured to correspond to an exterior surface of the first attachment means to increase feathering;

wherein at least two of the four distinct cutouts located in the second housing are contoured to correspond to an exterior surface of the second attachment means to increase feathering;

wherein the centerline of the first bearing intersects with a longitudinal axis of the yoke arm at only a first point; and

wherein the centerline of the second bearing intersects with the longitudinal axis of the yoke arm at only a second point.

5. The rotary system of claim **4**, wherein the first bearing and the second bearing are both located on a plane.

* * * * *